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PATENT SPECIFICATION

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(54) A HOUSE EXCHANGE TELEPHONE SYSTEM

(71) We, THE PLESSEY COMPANY LIMITED, a British Company of 2/60 Vicarage Lane, Ilford, Essex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a House Exchange telephone system and is a modification of the invention disclosed in our British Patent No. 1,437,031.

Patent 1,437,031 described a House Exchange telephone system including a plurality of extension line units which are radially connected to a switching matrix using a first conductor pair for each extension and to a common control unit using a second conductor pair for each extension, the first conductor pair being used for speech transmission and signalling to a public exchange whilst the second conductor pair is used for supplying power to the extension and for system signalling, the extension line units being successively connected to the common control unit in an associated time slot; and a number of exchange line units which are radially connected to the switching matrix and to the common control unit, wherein the switching matrix is arranged so that the first conductor pair of each extension line unit crosses the first conductor pair of each of the other extension line units at a unique crosspoint and also crosses a speech conductor pair for each exchange line unit at a unique crosspoint, the switching matrix including a crosspoint switching circuit at each of the said crosspoints and wherein the switching of the crosspoints is controlled in a time division multiplex mode.

According to the invention there is provided a House Exchange telephone system as claimed in any one of the Claims 1 to 12 of Patent No. 1,437,031 which includes a constant current source for supplying power to each of the extensions on the associated second conductor pair;

voltage modulation means including a transistor for each conductor of the second conductor pair, the emitter-collector circuit of each of the transistors being connected in series with the associated conductor and shunted by a resistance, and means for switching the transistors into, and out of, conductance in accordance with the information data being sent from the control unit in order to modulate the voltage supply to each of the extensions; first detection means for detecting the voltage modulation at each of the extensions, the first detection means being capacitively coupled to the associated second conductor pair and adapted to provide an output signal representative of the voltage modulation; voltage regulation means for each of the extensions; current modulation means for each of the extensions, the series resistance of each of the current modulation means being varied in a binary manner in accordance with the information data being sent from the associated extension, the series resistance variations effecting modulation of the current drawn from the constant current source at the extension line unit; resistive means responsive to the current modulation at the control unit to provide corresponding voltage variations; and second detection means for detecting the voltage variations at the control unit, the second detection means being capacitively coupled to the associated second conductor pair and adapted to provide an output signal representative of the voltage variations.

The foregoing and other features according to the invention will be better understood from the following description with reference to the accompanying drawings in which:

Figure 1 diagrammatically illustrates, in the form of a block diagram, a power feed and bidirectional signalling arrangement for the House Exchange telephone system according to the invention,

Figure 2 illustrates a practical circuit

arrangement for the balanced voltage modulator of Figure 1,

Figure 3 illustrates a practical circuit arrangement for the series voltage regulator of Figure 1,

Figure 4 illustrates a practical circuit arrangement for one of the balanced threshold detectors of Figure 1, and

Figure 5 illustrates a practical circuit arrangement for part of the other one of the balanced threshold detectors of Figure 1.

Referring to Figure 1 of the drawings, a power feed and bidirectional signalling arrangement for the House Exchange

1,437,031 is diagrammatically illustrated therein in the form of a block diagram and includes two equipment units which are interconnected by means of a single pair of

conductors and which are adapted to operate in a manner whereby powering of one of the equipment units is effected from a constant current source located at the

other one of the equipment units and whereby bidirectional signalling can be effected between the two equipment units.

The block within the dotted line 2 at the left hand side of Figure 1 represents the circuits of one equipment unit i.e. the signalling interface unit of the House

Exchange telephone system referred to in the preceding paragraph, and the block within the dotted line 1 at the right hand

side of Figure 1 represents the circuits of the other equipment unit i.e. an extension instrument of the House Exchange

telephone system. The two units 1 and 2 are interconnected by a single pair of conductors which are represented in Figure 1 by resistances RL, the maximum value of

RL being 50 ohms. The single conductor pair i.e. the line RL is fed from a voltage source VL, a low impedance source being preferred to a high

impedance source as regards the effect of interference. Likewise, the signal modulation and detection circuits are balanced as far as possible so as to provide

good longitudinal interference rejection. At the unit 2, the information data which is to be passed to the unit 1 via the line RL,

i.e. the 'data to line' signal modulates the line voltage using a balanced voltage modulator arrangement 3 which includes a

balanced voltage modulator connected to each side of the line RL and a logic level translator. The voltage modulation is detected at the unit 1 by means of a

balanced threshold detector 4. The detector 4 is connected to one side of the line RL by means of a capacitor C4 and its output is applied to a load 5 of the unit 1.

The load 5 is constituted by the logic circuits of the extension instrument. Since the line voltage at the unit 1 varies,

due to line signalling and line length variations, the supply voltage for the circuits of the unit 1 is derived from a series voltage regulator 6. The input impedance of the voltage regulator 6 is arranged to be 120 ohms in order to match the line RL at the upper signal frequencies.

The output from the voltage regulator 6 provides a 'primary' voltage reference for the balanced threshold detector 4 and for a

current modulator 7 which provides for signalling from the unit 1 to the unit 2. A 'secondary' voltage Vs for the load 5 is derived from a constant current source 8 in

order to prevent load variations from reflecting into the line RL and thence into the signal detectors.

Signalling from the unit 1 as just indicated, is by means of the current modulator 7. The series resistance of the

current modulator 7 is varied in a binary manner in accordance with the 'data to line' signals that are applied to the

modulator. This variation of the modulators series resistance effects modulation of the

current drawn through resistances RD1 and RD2 at the unit 2. The resistances RD1 and RD2 are each connected in series with a

separate one of the lines RL. The current variations are differentially detected at the

unit 2 in terms of the resulting voltage variations across the series resistances RD1 and RD2. These voltage variations or

pulses are a.c. coupled by the capacitors C1 and C2 into the unit's balanced threshold

detector 9 the output of which is a 'data from line' signal.

The combined values of the resistances RD and the output impedance of the line unit's balanced voltage modulator 3

approximate to 120 Ω so as to match the line RL.

The current modulation from the unit 1 is arranged so that the resulting voltage pulses on the line RL are of inverse polarity with

respect to the voltage pulses from the unit 2 in order to prevent the signals sent by the unit 1 from feeding back into its logic circuits via the balanced threshold detector

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The detailed arrangements and functions of the various circuits of Figure 1 will now be outlined in greater detail with reference

to Figures 2 to 5 of the drawings. With reference to Figure 2 of the

drawings, a circuit diagram of the constant current source CCS1 and the balanced voltage modulator arrangement 3 of Figure 1 are illustrated therein.

The constant current source CCS1 is formed by a transistor TR1 having the emitter thereof connected to the voltage source VL via a resistance R1, the base thereof connected to a zero voltage supply rail via a resistance R3 and to the voltage

source VL via a Zener diode D1, and the collector thereof connected to one side of the line via two series connected resistances R6 and RD1. The resistance R3 and the diode D1 are selected so that the potential of the base of the transistor TR1 is set to a value which is such that the resistance R1 and the transistor TR1 supply a constant current to the line through resistances R6, RD1 and two series connected resistances R9, RD2 regardless of the length of the line.

A capacitor C1 which is connected across the line, provides a low impedance so that the line is balanced by the resistances R6, RD1 and R9, RD2. Also, the capacitor C1 effectively shunts any interference on the line directly to earth i.e. to the zero volts supply rail.

The balanced voltage modulator arrangement 3 is formed by transistors TR2 to TR4 and their associated circuitry. The emitter-collector circuit of the transistor TR2 is connected in parallel with the resistance R6 and the emitter-collector circuit of the transistor TR4 is connected in parallel with the resistance R9. The collector-emitter circuit of the transistor TR3 is connected in series with a resistance R8 between the base of the transistor TR2 and the zero voltage supply rail. The base of the transistor TR2 is connected to the positive voltage supply rail via a resistance R5. The bases of the transistors TR3 and TR4 are connected to the zero voltage supply rail respectively via capacitances C2 and C3 and to a 'data to line' input terminal respectively via resistances R2 and R4.

When there is no 'data to line' signal applied to the base of the transistors TR3 and TR4 i.e. when the 'data to line' signal is low, the transistors TR3 and TR4 are switched off and, therefore, the voltage at the collector of the transistor TR3 and thereby at the base of the transistor TR2 will be high and transistor TR2 will be in a non-conducting state. Under these conditions the drop across the series connected resistances R6, RD1 and R9, RD2 is such that the line voltage is low.

When there is a high 'data to line' input signal at the base of the transistors TR3 and TR4, these transistors are caused to conduct and the collector voltage of the transistor TR3 will decrease and the transistor TR2 will, therefore, be caused to conduct. Under these conditions, the resistances R6 and R9 will respectively be shorted out by the transistors TR2 and TR4 and a positive voltage pulse will be sent from the unit 2 to the unit 1 via the line RL.

It should be noted that small changes in current due to signalling are absorbed, or supplied, by the capacitance C1.

Figure 3 illustrates the circuit diagram of

the series regulator 6, the current modulator 7 and the constant current generator 8 of Figure 1 with typical values for the various circuit components being indicated for the House Exchange telephone system application.

In Figure 3 the circuit of the series voltage regulator 6 is a well known type of circuit wherein the base, and hence the emitter of a transistor TR6 is held at a voltage defined by a reference zener diode Z1. The 120 Ω resistance R5 in the collector-base circuit of the transistor TR6 provides the necessary line-matching at the higher signal frequencies.

As previously outlined, the voltage supply for the load is derived from a constant current generator 8. The circuit of Figure 3 containing a transistor TR8 is a conventional constant current generator and it provides sufficient current to satisfy the peak 'steady' current for the load, any transient demand being provided by a capacitor C3 which is connected in shunt with the load. The constant current generator also provides sufficient current to ensure adequate voltage regulation from a reference zener diode Z2.

As previously outlined, signalling from the unit 1 of Figure 1 is effected by means of current modulation. The requirement of the circuits in this respect is that a minimum current change of 9 mA, should be effective in the two series resistances RD1 and RD2 in the unit 2 of Figures 1 and 2. In order that this change can be guaranteed with all lengths of line, a current change of 24—25 mA is required at the unit 1. A current modulator constituted by a transistor TR7 and its associated components is operated by the 'data to line' signals which are applied via a 15 K Ω resistance to the base of the transistor TR7. When this data signal is low the transistor TR7 is switched off and there is no current in the 430 Ω collector resistance R6 of the transistor. When the data signal is high, the transistor TR7 saturates and draws collector current I_c which is given in the following equation:—

$$I_c = \frac{V_p - 0.8}{R_6} = \frac{11.3 - 0.8}{430} = 24.4 \text{ mA}$$

wherein the figure 0.8 is the approximate voltage drop across the saturated transistor TR7 and a diode D3 in the emitter circuit of the transistor TR7.

On a long line, the current modulation results in a minimum current change of 9 mA in the series resistances RD, which, as illustrated in Figure 2, have a minimum value of 56 Ω . This gives a minimum differential voltage change of

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2x56x9x10⁻³ i.e. 1.0 volt and this differential voltage change is, as is illustrated in Figure 1, capacitively coupled by the capacitors C1 and C2 to the balanced threshold detector 9.

At the unit 2 signals from line are sampled coherently at instants when they are expected to be present. This process offers adequate protection against noise on the line.

At the unit 1 operation is asynchronous and any noise signal exceeding the detector threshold will be treated as a valid signal. For this reason it is necessary to provide as high a noise immunity as possible at the unit 1.

It should be noted that, whilst the modulator 7 and generator 8 of Figure 1 are illustrated in discrete component form in Figure 3, these units together with the load 5, the balanced threshold detector 4 and the associated circuitry could be in the form of an integrated circuit arrangement.

At the unit 2 of Figure 1, the balanced threshold detector 9 can be based on the well known long-tailed pair circuit and a typical arrangement of such a circuit is illustrated in Figure 4 of the drawings.

As illustrated in Figure 4, the long-tailed pair is constituted by transistors TR17 and TR18 and their associated circuitry, the differential voltage change on the line RL being capacitively coupled by the capacitors C1 and C2 of Figure 1 to the bases of the transistors TR17 and TR18. The data output i.e. the 'data from line' signal, of the circuit for application to the system's logic circuits is taken from the collector of a transistor TR16 whose base is resistively connected to the collector of the transistor TR18.

At the unit 1 of Figure 1 the threshold detector 4 is preceded by a linear, balanced amplifier the circuit of which is illustrated in Figure 5 of the drawings.

In Figure 5, a transistor TR9 and its associated circuitry constitutes a constant current source which ensures that two transistors TR10 and TR11 which are connected in a long-tailed pair configuration, operate in a non-saturating linear mode. The bias conditions on the transistors TR10 and TR11 are arranged to provide adequate swing at the collector of the transistor TR11 when the input, which is capacitively coupled via the capacitors C4 of Figure 1, is unbalanced by the presence of a line signal. If longitudinal noise is present, the base potentials of the transistors TR10 and TR11 are affected by an equal amount and their collector currents do not change. The output from the collector of the transistor TR11 is taken to the extension terminal logic via a simple

threshold detector which can be of any known type.

In an alternative arrangement of the circuit of Figure 5, the transistor TR9 and associated bias resistances can be replaced by a single resistance connected between the emitters of the transistors TR10 and TR11 and the VP voltage supply line.

WHAT WE CLAIM IS:—

1. A House Exchange telephone system as claimed in any one of the Claims 1 to 12 of Patent No. 1,437,031 which includes a constant current source for supplying power to each of the extensions on the associated second conductor pair; voltage modulation means including a transistor for each conductor of the second conductor pair, the emitter-collector circuit of each of the transistors being connected in series with the associated conductor and shunted by a resistance, and means for switching the transistors into, and out of, conductance in accordance with the information data being sent from the control unit in order to modulate the voltage supply to each of the extensions; first detection means for detecting the voltage modulation at each of the extensions, the first detection means being capacitively coupled to the associated second conductor pair and adapted to provide an output signal representative of the voltage modulation; voltage regulation means for each of the extensions; current modulation means for each of the extensions, the series resistance of each of the current modulation means being varied in a binary manner in accordance with the information data being sent from the associated extension, the series resistance variations effecting modulation of the current drawn from the constant current source at the extension line unit; resistive means responsive to the current modulation at the control unit to provide corresponding voltage variations; and second detection means for detecting the voltage variations at the control unit, the second detection means being capacitively coupled to the associated conductor pair and adapted to provide an output signal representative of the voltage variations.

2. A House Exchange telephone system as claimed in Claim 1 wherein the voltage modulation and the detection means are balanced in order to provide longitudinal interference rejection.

3. A House Exchange telephone system as claimed in Claim 1 or Claim 2 wherein the means for switching the transistors of the voltage modulation means into, and out of, conductance include another transistor having the collector-emitter circuit thereof connected in series with a first resistance

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2x56x9x10⁻³ i.e. 1.0 volt and this differential voltage change is, as is illustrated in Figure 1, capacitively coupled by the capacitors C1 and C2 to the balanced threshold detector 9.

At the unit 2 signals from line are sampled coherently at instants when they are expected to be present. This process offers adequate protection against noise on the line.

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At the unit 2 of Figure 1, the balanced threshold detector 9 can be based on the well known long-tailed pair circuit and a typical arrangement of such a circuit is illustrated in Figure 4 of the drawings.

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At the unit 1 of Figure 1 the threshold detector 4 is preceded by a linear, balanced amplifier the circuit of which is illustrated in Figure 5 of the drawings.

In Figure 5, a transistor TR9 and its associated circuitry constitutes a constant current source which ensures that two transistors TR10 and TR11 which are connected in a long-tailed pair configuration, operate in a non-saturating linear mode. The bias conditions on the transistors TR10 and TR11 are arranged to provide adequate swing at the collector of the transistor TR11 when the input, which is capacitively coupled via the capacitors C4 of Figure 1, is unbalanced by the presence of a line signal. If longitudinal noise is present, the base potentials of the transistors TR10 and TR11 are affected by an equal amount and their collector currents do not change. The output from the collector of the transistor TR11 is taken to the extension terminal logic via a simple

threshold detector which can be of any known type.

In an alternative arrangement of the circuit of Figure 5, the transistor TR9 and associated bias resistances can be replaced by a single resistance connected between the emitters of the transistors TR10 and TR11 and the VP voltage supply line.

WHAT WE CLAIM IS:—

1. A House Exchange telephone system as claimed in any one of the Claims 1 to 12 of Patent No. 1,437,031 which includes a constant current source for supplying power to each of the extensions on the associated second conductor pair; voltage modulation means including a transistor for each conductor of the second conductor pair, the emitter-collector circuit of each of the transistors being connected in series with the associated conductor and shunted by a resistance, and means for switching the transistors into, and out of, conductance in accordance with the information data being sent from the control unit in order to modulate the voltage supply to each of the extensions; first detection means for detecting the voltage modulation at each of the extensions, the first detection means being capacitively coupled to the associated second conductor pair and adapted to provide an output signal representative of the voltage modulation; voltage regulation means for each of the extensions; current modulation means for each of the extensions, the series resistance of each of the current modulation means being varied in a binary manner in accordance with the information data being sent from the associated extension, the series resistance variations effecting modulation of the current drawn from the constant current source at the extension line unit; resistive means responsive to the current modulation at the control unit to provide corresponding voltage variations; and second detection means for detecting the voltage variations at the control unit, the second detection means being capacitively coupled to the associated conductor pair and adapted to provide an output signal representative of the voltage variations.

2. A House Exchange telephone system as claimed in Claim 1 wherein the voltage modulation and the detection means are balanced in order to provide longitudinal interference rejection.

3. A House Exchange telephone system as claimed in Claim 1 or Claim 2 wherein the means for switching the transistors of the voltage modulation means into, and out of, conductance include another transistor having the collector-emitter circuit thereof connected in series with a first resistance



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between the base of one of the transistors of the voltage modulation means and one conductor of the second conductor pair, the base of the said one of the transistors being connected to the other conductor of the second conductor pair via a second resistance; a third resistance connected in series with the base of the said other transistor and an input terminal; a fourth resistance connected in series with the base of the other one of the transistors of the voltage modulation means and the input terminal; and first and second capacitances which respectively shunt the base-emitter circuits of the said other transistor and the said other one of the transistors.

4. A House Exchange telephone system as claimed in any one of the preceding claims wherein the voltage regulation means include a voltage regulator connected in series with one conductor of the second conductor pair and adapted to supply a first reference voltage for the current modulation means and the first detection means; a constant current generator connected in series with a zener diode across the output of the series voltage regulator and adapted to supply a second reference voltage for a load circuit of an extension instrument; and a capacitor which is connected in shunt with the load circuit and adapted to satisfy transient feed current demands.

5. A House Exchange telephone system as claimed in Claim 4 wherein the current modulation means, the constant current generator, the load circuit and the first detection means are in the form of an integrated circuit.

6. A House Exchange telephone system as claimed in Claim 4 wherein the series voltage regulator includes a first transistor, the emitter-collector circuit of which is connected in series with the said one conductor of the second conductor pair and the base of which is connected to the other conductor of the second conductor pair via a zener diode and to the collector via a resistance having a value which effects

impedance matching between the second conductor pair and the series voltage regulator.

7. A House Exchange telephone system as claimed in Claim 4 or Claim 6 wherein the current modulation means includes a second transistor the base of which is resistively connected to a signal input and the emitter-collector of which is connected to the first reference voltage supply, the emitter being connected to one side of the first reference voltage supply via a diode.

8. A House Exchange telephone system as claimed in any one of the preceding claims wherein the resistive means consist of a series resistance for each conductor of the second conductor pair.

9. A House Exchange telephone system as claimed in any one of the preceding claims wherein the first detection means include a voltage threshold detector connected in series with a linear balanced amplifier, the inputs of the amplifier being capacitively coupled to a separate one of the conductors of the second conductor pair.

10. A House Exchange telephone system as claimed in any one of the preceding claims wherein the second detection means include third and fourth transistors connected in a long-tailed pair configuration, the base of each of the transistors being capacitively coupled to a separate one of the conductors of the second conductor pair; and a fifth transistor the base of which is resistively connected to the collector of one of the third and fourth transistors and the collector of which is connected to an output terminal of the second detection means.

11. A House Exchange telephone system substantially as hereinbefore described with reference to the accompanying drawings.

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